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**Evaluation of  
Remedial Investigation  
and  
Feasibility Study  
for the  
KUMMER SANITARY LANDFILL**

prepared for

**MINNESOTA  
STATE  
UNIVERSITY  
SYSTEM**

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**STANLEY CONSULTANTS**

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## SUMMARY

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The Kummer Sanitary Landfill (landfill) operated from 1971 to 1984 receiving waste from both households and industry in the area around Bemidji, Minnesota. In 1984 the Minnesota Pollution Control Authority (MPCA) detected volatile organic compounds (VOC) in residential wells east of the landfill. MPCA determined that the landfill was the source. The landfill was closed and in 1986 was put on the National Priorities List.

The MPCA working with the United States Environmental Protection Agency (EPA) investigated the problem of hazardous substances leaving the landfill and contaminating the ground water beneath and to the east of the landfill. The following solution divided into three parts called "operable units" was adopted:

1. Provide an alternate drinking water supply for residences in the affected area.
2. Install an impermeable cover (cap) over the landfill to prevent the infiltration of rain water into the landfill which would leach contaminants into the ground water.
3. Extract ground water from beneath the eastern edge of the landfill by a system of wells and pumps and treat the ground water to remove or destroy hazardous contaminants and discharge the water to an infiltration pond.

The first operable unit has been implemented and all but four residences now get their water from the City of Bemidji water system. Local ordinance requires hook-up to the City water system. Legal action is being taken against the remaining four to force them to also connect. In addition, a well advisory has been issued by the Minnesota Department of Health (MDH) for the area. Existing wells are to be capped and no new wells are allowed.

Funding for the second operable unit is presently being provided by a group of industries identified by the EPA as Potentially Responsible Parties (PRPs) who contributed hazardous waste to the site. The MPCA has let bids for this work and construction is anticipated to be completed in 1991.

The EPA has also alleged Bemidji State University (BSU), the City of Bemidji, Corecraft, Inc. and Charles, Ruth and Jon Kummer are PRPs and on June 28, 1991 ordered them to implement operable unit three of the EPA remedy.

BSU disposed of household type wastes and flyash from its boiler system at the landfill from 1971-1984. BSU obtained the required permit from MPCA for flyash disposal. The EPA contends that barium was present in the flyash and has been detected in the ground water east of the landfill. The EPA asserts that barium is a hazardous substance. The EPA has conceded in meetings with BSU that BSU did not bring vinyl chloride to the landfill. Thus, EPA has identified BSU as a PRP based solely on the presence of barium in their flyash.

BSU does not dispute that barium was present in the flyash. Tests were performed on the BSU flyash in 1981 in order to obtain a MPCA permit to dispose of flyash at the landfill. These tests confirmed the presence of barium in the flyash but in concentrations well below those established for a hazardous material pursuant to the EPA's extraction procedure toxicity test (EP tox). The concentration of barium in the extract was 4.3 mg/l; the EP toxicity limit was 100 mg/l (the same limit now adopted under the new toxicity characteristic leaching procedure). Examination of other potential criteria for classifying a substance as hazardous discloses a similar lack of justification for barium being identified as hazardous.

The Minnesota State University System of which BSU is a member strongly questions the validity of the EPA's evaluation of the site and selection of a method for treatment of the ground water. This report presents a technical review of the EPA's evaluation in the Remedial Investigation (RI) of the risk of endangerment to public health and environment caused by the contaminated ground water and the selection in the Feasibility Study (FS) of possible treatment methods for the ground water. The following tasks were performed in this evaluation:

- risk assessment used in the RI was compared to EPA risk assessment guidance.
- the use of the risk assessment in the selection of alternatives was evaluated.
- an evaluation was performed to determine if the risk assessment supports the active treatment of the ground water for organic and inorganic contaminants.

- technologies proposed in the FS for the treatment of the ground water were evaluated to determine the reasonableness of their use to achieve the treatment objectives.
- alternative technologies not considered in the FS were evaluated.
- independent FS level cost estimates were prepared for the treatment alternatives considered.
- methods used in the FS to compare treatment alternatives was evaluated.

The evaluation revealed that the risk assessment performed in the RI suffers from three major faults:

- 1) the risk assessment is a screening-level assessment, not a site-specific one as required by EPA guidelines, resulting in gross overestimation of risk and corresponding over estimation of technology and associated costs required to address that risk;
- 2) the remedy for cleanup of ground water has been selected to remove five VOCs identified as contaminants of concern and barium from the water; but, there is no health risk assessment of the barium that is present and there is no reason to believe barium presents a health risk;
- 3) it appears that applicable or relevant and appropriate requirements (ARARs) were not properly identified and that unnecessary cleanup of barium and possibly of VOCs has been recommended.

In addition, even though the RI concluded there was no environmental impact, ambient water quality criteria (AWQC) appear to have been inappropriately compared to ground water concentrations without a consideration of concentrations that might be discharged to surface water bodies.

Remedial alternatives were developed in the FS based upon the following response categories:

- hydraulic controls
- ground water treatment
- effluent management

Alternatives were evaluated and screened with respect to the following:

- effectiveness
- technical feasibility and implementability
- adverse effects on the environment
- cost

Four organic treatment technologies were considered: air stripping; advanced oxidation process (AOP); discharge to a publicly owned treatment works (POTW); and bioremediation. Only AOP passed screening and was carried forward for further evaluation.

The evaluation of alternatives performed in the FS contained several flaws. The FS exhibits an incomplete understanding of the technologies considered for treatment and lacks treatability test data for organic treatment processes which would have demonstrated their effectiveness for the landfill as well as clarified the need for pretreatment of inorganics. Specific examples include:

- Recommended vapor phase carbon treatment and effluent polishing by carbon at the air stripper was not added to treat any known contaminants and is not effective for vinyl chloride, the principle contaminant of concern.
- Effluent polishing by carbon after treatment by AOP is probably not necessary. Treatability tests to confirm were not performed.
- Additional consideration should have been given to pretreatment requirements for removal of inorganics prior to treatment for organic removal. Treatability studies or bench scale tests would have identified the pretreatment required, if any.



- The precipitation process described by the FS for pretreatment of inorganics is not precipitation but is coagulation/flocculation. The process as described would not give any significant removal of solubilized inorganics including barium.
- Bioremediation was not seriously evaluated. Different methods of nutrient addition were not discussed and treatability was not adequately addressed. Cost estimates were not prepared.

The development and evaluation of alternatives in the FS should be focused on the five contaminants of concern and ARARs identified in the RI. Focus is misplaced in the FS when the primary reason for pretreatment is stated to be for barium removal. Pretreatment for removal of inorganics is required only as necessary to remove inorganic compounds which would inhibit the treatment of organics. Neither the RI nor the FS indicate the need for barium removal as a contaminant of concern.

The air stripping and bioremediation alternatives were dropped from further consideration during the screening process. No reason was given for not carrying them forward for further evaluation and no reason is apparent in the FS.

Based on screening results, the following alternatives were carried forward in the FS for detailed evaluation in the FS:

- Alternative I - No further action or limited action with non-point source discharge to Lake Bemidji.
- Alternative II - Active downgradient controls, on-site treatment by AOP and lime soda softening, and point source discharge to Lake Bemidji.
- Alternative III - Active downgradient controls, on-site treatment by AOP, possible on-site treatment by lime soda softening, and on-site disposal in an infiltration pond.

The evaluation of Alternative I suffered from four major faults and the findings were incorrectly reported in the summary of the evaluation of alternatives presented in Tables 4-1 and 4-4 of the FS.

- The FS found Alternative I to be "likely protective" of human health and the environment; without any technical basis, the Record of Decision (ROD) contradicted the FS and found it to be "not protective". Data in the FS strongly supports a finding of "protective".
- A waiver of ARARs based on the alternate water supply and institutional controls was not considered which is contrary to EPA guidelines.
- Table 4-4 of the FS incorrectly describes Alternate I as "probably effective" with regard to long term effectiveness. This table should be consistent with Table 4-1 which calls Alternative I "effective".
- The text of the FS describes Alternative I as "effective" with regard to short term effectiveness. However, Table 4-1 calls it "probably ineffective" and Table 4-4 calls it "probably effective".

These errors in evaluation resulted in an incorrect lowering of the perceived performance of Alternative I as compared with the other alternatives and possibly precipitated the unwarranted rejection of this alternative in the ROD.

Costs of the ground water treatment alternatives were given in the FS for a range of possible operating years giving what may be a false impression that the remedy will be complete in 4 years. Experience indicates that concluding such pump and treat operations are rather difficult, especially within 4 years. The FS optimistically estimated the minimum present worth cost for Alternative III to be 3.0 million dollars. However, the present worth could reach as much as 11.5 million dollars if operated for 30 years. The long term effectiveness of any alternative depends on the effectiveness of the landfill cover. The effect of different cover designs was not considered in the FS.

New costs were calculated for all the ground water treatment alternatives considered. The costs are generally much higher than the costs presented in the FS. The cost of remediation using the AOP alternative with lime-soda softening is nearly double what was estimated in the FS.

The net effects of the various flaws in the risk assessment and alternative evaluation are

- unwarranted emphasis was placed on the inorganic contaminants, particularly barium.
- the risk associated with the site is greatly exaggerated.
- treatment alternatives were not correctly developed and evaluated resulting in unnecessary treatment being required, viable alternatives being dropped from consideration and the cost of ground water treatment being grossly understated.
- the no action alternative was not consistently and correctly evaluated resulting in its being dropped from consideration in the ROD.

### Conclusion

An examination of Alternative I (plume monitoring) for operable unit no. 3, ground water, shows it to fully meet the remedial objectives identified in the FS. Those objectives given in Section 2 of the FS are to provide a safe drinking water supply down-gradient of the landfill and to prevent significant impact on the surface water quality at Lake Bemidji. Data from the risk analysis performed in the RI indicates human health risk may quite possibly be less than  $10^{-6}$  without any action. The provision of an alternate water supply (operable unit one) to residences down-gradient of the landfill plus the well advisory issued by the MDH assures the virtual elimination of any risk to human health. Ground water modeling performed in the FS demonstrated that the landfill cover (operable unit two) presently under construction will protect the water quality of Lake Bemidji from any significant impacts. Besides being fully protective of human health and the environment, the plume monitoring alternative complies with the ARARs via operable unit one. Long term protection is provided by the alternate water supply and institutional controls. Section 3.3.1 of the FS states that modeling results also indicate that plume monitoring appears to achieve the ground water remedial action objective of preventing significant contaminant migration to shallow ground water down gradient of the landfill due to the landfill cover being implemented under operable unit 2.

A comparison of alternatives shows that plume monitoring is just as effective as the other alternatives in achieving these goals but at a much lower cost. Therefore, based on these criteria, plume monitoring is the most appropriate remedy.

# **COST SUMMARY**

<b><u>DESCRIPTION</u></b>	<b><u>FEASIBILITY STUDY</u></b>			<b><u>INDEPENDENT ESTIMATE</u></b>		
	<b><u>CAPITAL COST</u></b>	<b><u>O &amp; M</u></b>	<b><u>PRESENT WORTH</u></b>	<b><u>CAPITAL COST</u></b>	<b><u>O &amp; M</u></b>	<b><u>PRESENT WORTH</u></b>
<b>GROUND WATER EXTRACTION SYSTEM &amp; RECHARGE POND</b>	<b>530,000</b>	<b>72,000</b>	<b>1,200,000</b>	<b>--</b>	<b>--</b>	<b>--</b>
<b>AIR STRIPPING</b>	<b>320,450</b>	<b>121,000</b>	<b>1,500,000</b>	<b>190,000</b>	<b>165,000</b>	<b>1,700,000</b>
<b>LIQUID &amp; VAPOR PHASE CARBON</b>	<b>208,800</b>	<b>8,000</b>	<b>300,000</b>	<b>--</b>	<b>--</b>	<b>--</b>
<b>PRECIPITATION</b>	<b>320,000</b>	<b>200,000</b>	<b>2,200,000</b>	<b>513,000</b>	<b>480,000</b>	<b>5,000,000</b>
<b>ADVANCED OXIDIATION PROCESS</b>	<b>340,750</b>	<b>164,000</b>	<b>1,900,000</b>	<b>800,000</b>	<b>350,000</b>	<b>4,100,000</b>
<b>LIQUID PHASE CARBON</b>	<b>104,400</b>	<b>8,000</b>	<b>200,000</b>	<b>--</b>	<b>--</b>	<b>--</b>
<b>LIME-SODA SOFTENING</b>	<b>400,000</b>	<b>270,000</b>	<b>2,900,000</b>	<b>513,000</b>	<b>585,000</b>	<b>6,000,000</b>
<b>NO ACTION</b>	<b>73,000</b>	<b>24,000</b>	<b>300,000</b>	<b>--</b>	<b>--</b>	<b>--</b>

**BACKGROUND**

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The Kummer Sanitary Landfill (landfill) operated from 1971 to 1984 receiving waste from both households and industry in the area around Bemidji, Minnesota. In 1984 the Minnesota Pollution Control Authority (MPCA) detected volatile organic compounds (VOC) in residential wells east of the landfill. MPCA determined that the landfill was the source. The landfill was closed and in 1986 was put on the National Priorities List.

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BSU does not dispute that barium was present in the flyash. Tests were performed on the BSU flyash in 1981 in order to obtain a MPCA permit to dispose of flyash at the landfill. These tests confirmed the presence of barium in the flyash but in concentrations well below those established for a hazardous material pursuant to the EPA's extraction procedure toxicity test (EP tox). The concentration of barium in the extract was 4.3 mg/l; the EP toxicity limit was 100 mg/l (the same limit now adopted under the new toxicity characteristic leaching procedure). Examination of other potential criteria for classifying a substance as hazardous discloses a similar lack of justification for barium being identified as hazardous.

The Minnesota State University System of which BSU is a member strongly questions the validity of the EPA's evaluation of the site and selection of a method for treatment of the groundwater. This report presents a technical review of the EPA's evaluation of the risk of endangerment to public health and environment caused by the contaminated groundwater and the selection of a treatment method for the groundwater.

## 2.1 CONTAMINANTS OF CONCERN

Ground water adjacent to and down gradient of the landfill has been identified to be contaminated due to operations at the landfill. The EPA has identified five contaminants of concern due to their concentration, frequency of detection, mobility and their designation as known human carcinogens:

- tetrachloroethane (PCE)
- trichloroethene (TCE)
- trans; 2-dichloroethene (tDCE)
- vinyl chloride
- benzene

Several inorganic constituents were also identified because of their high concentrations as compared to some of the regulatory limits. While identified, these seven inorganic constituents were not considered by the EPA in the same manner or detail of analysis as the above five contaminants of concern. The seven identified inorganic compounds are:

- aluminum
- arsenic
- barium
- iron
- manganese
- nickel
- nitrate

For the purpose of this independent evaluation, the following table describes the range of concentrations of the contaminants of concern in the remediation area and anticipated quality of ground water to be recovered for treatment. The "Design Basis Concentration" is the anticipated concentration in the ground water pumped for treatment and is taken from Table 3-5 of the Feasibility Study (FS). According to the FS, the design basis concentration is the "Average Concentration" for the wells shown in Table 2-5. However,

the average concentrations from Table 2-5 do not correlate with the values in Table 3-5. The difference is not significant. The actual average values from Table 2-5 are shown in the right column.

<u>Contaminant of Concern</u>	<u>Range of Observed Concentration (µg/L)</u> <u>(FS Page 1-9)</u>	<u>Design Basis Concentration (FS Table 3-5)</u> <u>(µg/L)</u>	<u>Average Concentration (FS Table 2-5)</u> <u>(µg/L)</u>
PCE	1.0-12	--	2
TCE	1.0-6.8	--	--
tDCE	1.3-35	5	4
vinyl chloride	3.0-94	33	31
benzene	1.0-6	4	3

The treatment technologies being considered must be able to reduce the levels of contaminants of concern in the ground water recovered for treatment to below the maximum concentration allowed (as discussed on page 2-3).

Inorganic compounds whose concentrations are evaluated are shown in the table below. The average values for inorganic compounds in Table 3-5 of the FS were incorrectly calculated for one well only. The correct average concentration for all wells taken from Table 2-6 is shown in the right hand column. The average concentrations of these compounds in the ground water recovered for treatment (shown in the column labeled "Average Concentration") are expected to be below the maximum concentration allowed. Removal of inorganic compounds will, therefore, not be required.

<u>Inorganic Compound</u>	<u>Range of Observed Concentration (µg/L)</u> <u>(FS Table 2-6)</u>	<u>Design Basis Concentration (FS Table 3-5)</u> <u>(µg/L)</u>	<u>Average Concentration (FS Table 2-6)</u> <u>(µg/L)</u>
Arsenic	5.4-22.2	14	15
Barium	36-2290	81	657
Iron	23-19500	273	4969
Manganese	21-1890	368	634
Nickel	35-149	70	68



The Record of Decision (ROD) asserts that the clean up criteria for the five contaminants of concern and the seven inorganic compounds should be the Safe Drinking Water Act Maximum Contaminant Levels (MCLs). The following table addresses the MCL for each contaminant of concern and the seven inorganic compounds.

<u>Contaminant/Compound</u>	<u>MCLs</u> <u>(<math>\mu</math>g/l)</u>
tetrachloroethylene (PCE)	5
trichloroethylene (TCE)	5
trans-1,2-dichloroethylene (tDCE)	100
vinyl chloride	2
benzene	5
Aluminum	50
Arsenic	50
Barium	2,000*
Iron	300**
Manganese	50**
Nickel	150***
Nitrate-N	10,000

\* 1991 promulgated MCL, effective January 1, 1993

\*\* Secondary drinking water standard

\*\*\* No MCL for Nickel. 150 is the limit recommended by the State of Minnesota

The current limit of 1000  $\mu$ g/l for barium was used in the ROD. A new limit of 2000  $\mu$ g/l was promulgated by the EPA in July 1991 but not made effective until January 1993 in order to allow treatment facilities to come into compliance with the new standard. It would be reasonable to assume that this standard will be in effect by the time any significant remedial action for the ground water commences.

## **2.2 PUBLIC HEALTH ASSESSMENT**

This evaluation is intended to 1) compare the risk assessment approach used to EPA risk assessment guidance, 2) evaluate whether the risk assessment was properly used in the FS and the selection of alternatives, 3) determine whether the risk assessment supports the decision for active treatment of the ground water for VOCs and inorganics, and 4) recommend whether further risk assessment is necessary.

## **2.3 TREATMENT ALTERNATIVES**

This evaluation is intended to 1) review the treatment technologies considered in the FS and evaluate the reasonableness of their use in achieving the treatment objectives; 2) propose alternative treatment methods which were not considered in the FS; and 3) perform an independent FS level cost estimate of the technologies considered in the FS plus any others proposed. This evaluation is limited to considering only the ground water treatment and by accepting the position taken in the FS with regard to the following:

- Active downgradient hydraulic controls will be used.
- Discharge of treated groundwater will be to an infiltration pond.
- Cleanup goals are the MCLs for the contaminants of concern.

Comparing the MCLs to the expected concentration of inorganic compounds in the flow of ground water to be pumped from the proposed recovery wells, the only inorganic compounds above their MCL are iron and manganese. Since these MCLs are secondary standards (not health based) and are not enforceable under CERCLA, they will not be considered. The expected concentration of barium is 657  $\mu\text{g/l}$  which is well below its MCL of 2000  $\mu\text{g/l}$ . Therefore, treatment for removal of inorganic compounds is not required.

The only consideration given to the treatment of inorganics will be that which is required as a pretreatment for the organic treatment process. This position is supported by the lack of any finding in the Remedial Investigation (RI) of any health risk attributable to inorganic contaminants. Also, the inorganic treatment methods considered in the FS appear to have been selected primarily upon pretreatment requirements and not the removal of the inorganic compounds.

The risk assessment suffers from three major faults: first, it is a screening-level or preliminary assessment, not a site-specific one in accordance with EPA guidelines, resulting in gross overestimation of risk and correspondingly gross overestimation of the technology and associated costs required to address that risk; second, the remedy for cleanup of ground water has been selected to remove VOCs and barium from the water, but there is no health risk assessment for the barium that is present and there is no reason to believe barium presents a health risk; and third, it appears that all applicable, relevant and appropriate regulations (ARARs) were not properly identified and that unnecessary cleanup of barium and possibly of VOCs has been recommended. In addition, for the environmental evaluation, ambient water quality criteria (AWQC) appears to have been inappropriately applied to ground water without a consideration of concentrations that might be discharged to surface water bodies.

### 3.1 BASELINE HUMAN HEALTH RISK ASSESSMENT (Remedial investigation, Chapter 8)

#### Data Evaluation and Hazard Identification

As stated on page 8-1 of the RI, data evaluation is one of four critical steps of the risk assessment process. However, maximum chemical concentrations were used in the evaluation of chemical intake from ground water. This is not in accordance with EPA guidance for conducting a site-specific assessment. Upper confidence limits on the means, not maximum values, should be used to represent reasonable maximum exposure concentrations.

A screening-level risk assessment was performed in the RI using the maximum concentrations of the contaminants of concern in order to see if a potential for risk exists. If potential risks are identified by screening, EPA guidelines state that a more sophisticated site-specific evaluation should be performed in order to estimate potential risk and need for remediation. The EPA guidance document (RAGS; 1989) states on page 6-25 "the assessor may wish to use the maximum concentration from a medium as the exposure concentration for a given pathway as a screening approach to place an upper bound on exposure. In these

cases it is important to remember that if a screening level approach suggests a potential health concern, the estimates of exposure should be modified to reflect more probable exposure conditions." Modeled concentrations at identified exposure points should be used for a site-specific, baseline risk assessment. This was not done. The screening method used was simplistic, overly conservative, and results in an inflated estimate of potential risk. The results of this screening level assessment may be used to justify the need for a site-specific assessment but can not be used to justify a specific remedial action.

In order for barium to be a focus of the selected remedy, it should first have been identified as a site hazard so that its potential impact on human health could be evaluated. Its omission from the risk assessment demonstrates a fatal flaw of the study and remedial action resulting therefrom. Only five chemicals identified as the five contaminants of concern (benzene, trans-1,2-dichloroethylene, tetrachloroethylene, trichloroethylene, and vinyl chloride) were evaluated by the EPA. Even had barium been included, we believe it would not have demonstrated any significant risk or any need for separate remedial action.

Vinyl chloride was identified as the most significant contaminant of concern. It comprises more than one half of the total of all contaminants of concern and poses the greatest health risk. However, the data quality objectives failed to note that the Contract-required Detection Limit (CRDL) and the Method Detection Limit (DML) for vinyl chloride are both 10 µg/L, while the MCL is 2 µg/L. While guidance (EPA, 1991) states that SQLs (sample quantitation limits) are more appropriate than CRDLs for risk assessment, SQLs were not identified. Alternate analytical methods with lower detection limits should have been selected for vinyl chloride so that potential health risks could be properly evaluated.

### **Exposure Assessment**

Complete exposure pathways have not been identified for current or future exposures. This is a critical step in a risk assessment, as stated in Chapter 6, Exposure Assessment, of the EPA Risk Assessment Guidance for Superfund Sites (RAGS) (EPA, 1989). These exposure pathways are the foundation of the conceptual site model, which is also described in detail in the guidance document, "Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites" (EPA, 1991). The identification of exposure pathways has four components, none of which were performed in this analysis:

- Identify current or future exposed populations
- Identify exposure points (locations where humans are actually or potentially exposed)
- Determine exposure point concentrations
- Identify exposure assumptions uncertainties and limitations, and their impact on the risk assessment.

The selection of the wells and concentrations to be evaluated is particularly confusing since Figure 1-6 in the RI shows a "general area of contaminated water wells" that does not overlap at all with the "contaminant isopleth map" (Figures 3-9 and 3-10) or the "vinyl chloride plume" (Figure 8-1).

The "shower model" used by the EPA in this risk assessment is a simplified screening model that is overly conservative in estimating exposure to VOCs. This screening model assumes 100% release of the VOCs from the water to the shower room air. Other, more realistic models are available. For example, Foster and Chrostowski (1987) created a more dynamic model that takes into account the many variables (such as the partition coefficient) that influence the release of VOCs from water and subsequent accumulation in the shower room air. Shower models do not estimate the potential health risks for chemicals that are not volatile, such as barium.

As a result of the conservative choice of chemical concentrations and the conservative exposure assumptions, the exposure that has been evaluated is greater than the "greatest exposure that is reasonably expected to occur" (EPA guidance, as stated on p. 8-4 of the RI) and therefore the analysis is not relevant to human health risks at the site.

### **Toxicity Assessment**

Values identified as referenced doses and slope factors for the contaminants of concern are all correct according to EPA sources except for the oral slope factor for vinyl chloride, which is 1.9/mg/kg/day; the value used, 2.3/mg/kg/day, was correct at the time the RI was published. The oral slope factor was lowered in 1990. This lower values reduces the total potential cancer risk by about 18%, since ingestion of vinyl chloride makes the largest contribution to the site risk (see below).

### Risk Characterization

While the calculations appear to have been performed correctly according to the formulas and variable values described in the text, they are fundamentally flawed because the estimates of exposure were not modified after the screening level analysis to reflect more probable exposure conditions. As previously mentioned, the exposure assumptions and chemical concentrations used in the RI are not appropriate for a site specific risk analysis.

The EPA cancer risk range has been changed since the publication of the report from the range given on page 8-8. Instead of  $1 \times 10^{-4}$  to  $1 \times 10^{-7}$ , it is now be  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$ , as stated in the EPA's National Contingency Plan (March, 1990).

Of the three pathways that were evaluated (ingestion of water, dermal exposure through bathing, and inhalation exposure through showering) and of the 5 contaminants of concern that were evaluated, ingestion of vinyl chloride in water is the major contributor to the estimated cancer risk. This exposure scenario assumed that an adult would drink 2 liters of water every day for 30 years, and that the water contains the maximum concentration of contaminants of concern detected in any wells sampled, regardless of location. The assumption is so conservative and unrealistic that it renders the entire analysis useless as a site-specific assessment and invalidates any conclusions drawn therefrom which support ground water remediation.

EPA guidance (EPA, 1989) states that "For Superfund exposure assessments, intake variable values for a given pathway should be selected so that the combination of all intake variables result in an estimate of the reasonable maximum exposure (RME) for that pathway . . . some intake variables may not be at their individual maximum values but when in combination with other variables will result in estimates of the RME" (page 619, EPA, 1989). So, for example, if the updated slope factor for vinyl chloride is used, and the intake of total water-derived beverages is assumed to be 1.4 liters for 350 days of each of 30 years, and the concentration at an actual or potential exposure point is, for example 5  $\mu\text{g/L}$ , then the upper bound on the cancer risk is estimated to be  $7.8 \times 10^{-5}$  for vinyl chloride which is considerably less than the risk of  $3 \times 10^{-3}$  estimated in the RI.

Equally significant is the complete absence of any health-based evaluation of the potential risk posed by barium.

### 3.2 FEASIBILITY STUDY

The recent directive from the EPA, OSWER Directive 9355.0-30 (April 1991), clearly states that "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than  $10^{-4}$ , action generally is not warranted. However, if MCLs . . . are exceeded, action generally is warranted." Data available from the RI does not support treatment of ground water based on risk since a site specific risk assessment was not performed. Had a risk assessment been performed per EPA guidelines, the risk may quite possibly have been found to be less than  $1 \times 10^{-4}$ . Indeed, the risk when considering the alternate water supply and institutional controls (well advisory) is virtually zero. Action based on MCLs alone may be questionable because an alternate water supply is provided and institutional controls are in place.

### 3.3 USE OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

#### Human Health Evaluation

The current MCL for barium is 2 mg/l (2000  $\mu$ g/L) (Federal Register, July 1, 1991). The MCL was 1 mg/l (1,000  $\mu$ g/L) at the time the RI was written. It appears that the highest detected level of barium is 2290  $\mu$ g/L in Well 2A. Three other wells had barium levels between 1000 and 2000  $\mu$ g/L; all other wells had levels below the CRDL of 200  $\mu$ g/L except for one where the value was estimated due to analytical interference. While the one well exceeded the MCL of 2000  $\mu$ g/L, it is not an identified exposure point, and therefore it cannot be assumed that current or future receptors will be exposed to barium at concentrations exceeding the MCL. Furthermore, the alternate water supply and well advisory should serve to eliminate the possibility of future receptors.

The MCL for vinyl chloride is 0.002 mg/l (2  $\mu$ g/L). Again, this risk assessment did not identify potential chemical concentrations at exposure points by measuring or modeling as recommended by the EPA, so it cannot be determined whether current or future receptors may be exposed to vinyl chloride at concentrations that exceed the MCL.

### Environmental Evaluation

The use of Ambient Water Quality Criteria (AWQCs) as ARARs for ground water is questionable. See p. 2-5 of the FS. There is no health basis for using these numbers. These numbers represent concentrations safe for consumption of aquatic life living in surface water containing them. These AWQCs would only be appropriate if chemicals were discharged to surface water and were not diluted by existing surface water. No surface water impact has been observed, and modeling predicted insignificant discharge (ie. discharge into Lake Bemidji will occur in 34 years and will not violate any current AWQC). The ROD and the RI both state that ecological risk is not considered significant.

### Recommendations

This risk assessment is at best a screening approach that overstates potential risk, rather than a reasonable estimation of risk upon which a proper remedy can be based. Although there appears to be no current exposure to vinyl chloride as all residents use municipal water, MCLs have been established as cleanup standards. Vinyl chloride did exceed its MCL in several samples taken from monitoring wells and two samples taken from residential wells. Even if MCLs have to be met, the questions become where must MCLs be met. There exists no demonstrated actual exposure points and the use of data from monitoring wells located in the roadway adjacent to the landfill as hypothetical exposure points is not reasonable. Indeed it would appear that future receptors will never be exposed to the water proposed to be treated per the selected remedy.

Clearly, the risk assessment would need to be revised before potential risk at exposure points can be determined. If, however, all parties recognize that there will never be exposure to this water at a residential usage level and that MCLs are not appropriate cleanup levels, a new risk assessment would not even be necessary.

The risk assessment does not in any way support the decision to treat the ground water for barium. Barium was not evaluated. Since all water users are connected to City water supply or in litigation to be so connected and with the MDH well advisory in effect, it appears that there is no current or potential future exposure to barium. The single exceedance of the new barium MCL is based on one sample of one well. Revision of the risk



assessment for the sake of barium is not necessary; agreement on the use of the new MCL, the point of compliance, and the method of determining compliance is more important.

### **3.4 REFERENCES**

Foster, S.A. and P.C. Chrostowski. 1987. Inhalation exposure to volatile organic contaminants in the shower. Paper 84-42.6 Presented at the Annual APCA meeting, New York, N.Y. June 21-26.

U.S. Environmental Protection Agency (EPA). 1989. Risk Assessment Guidance for Superfund. Volume 1. Human Health Evaluation Manual (Part A). EPA/540/1-89/-002.

U.S. Environmental Protection Agency (EPA). 1991. Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites. EPA/540/P-91/001; OSWER Directive 9355.3-11.

**ALTERNATIVE 1 - NO FURTHER ACTION / PLUME MONITORING**

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**4.1 PROCESS DESCRIPTION**

The no further action/plume monitoring alternative consists of monitoring the plume of ground water east of the landfill. This alternative does not include any treatment of the ground water and is premised upon the remedies already selected for operable units one and two:

1. Provide an alternate drinking water supply from the City of Bemidji water system for residences in the affected area.
2. Install an impermeable cover (cap) over the landfill to prevent the infiltration of rain water into the landfill which would leach contaminants into the ground water.

At the present time, all but four residences are connected to the alternate water supply. Court proceedings are underway to force the connection of these four residences. Work on the cap is currently underway and is expected to be completed in 1991.

The plume monitoring alternative requires the following action in addition to implementation of the selected remedies for operable units one and two.

- Removal of off-site monitoring wells installed during the remedial investigation (if required by property owners).
- Ground water quality monitoring for a period of 30 years or more in order to track the plume, and institutional controls.

The MDH recently established institutional controls by issuing a well advisory for the affected area which requires the capping of existing wells and bans construction of any new wells.

## **4.2 EVALUATION**

Based upon the ground water modeling results contained in Appendix B of the FS, plume monitoring is protective of the environment. Modeling results indicate that the contaminants of concern do not reach Lake Bemidji in detectable amounts until about 34 years after installation of the landfill cap. The level of contaminants entering the lake will be below current surface water quality standards. Total organic concentration beyond this time is likely to remain below the proposed surface quality standard for vinyl chloride thus achieving the objective of protection of the environment. Modeling did not consider any inorganic contaminants. Barium exceeded the newly promulgated MCL of 2 mg/l at only one well with a concentration of 2.29 mg/l. It can safely be assumed that the concentration of barium discharging into Lake Bemidji in 34 years will be below the current MCL. In addition, protection of human health is provided by the alternate water supply provided under operable unit one and institutional controls (i.e., well advisory) both of which have been implemented. Section 3.3.1 of the FS states that modeling results also indicate that the plume monitoring alternative appears to achieve the ground water remedial action objective of preventing significant contaminant migration to shallow ground water down gradient of the landfill due to the landfill cover being implemented under operable unit two.

## **4.3 COST ESTIMATE**

No independent cost estimate was developed for this alternative. The FS estimated a capital cost of \$73,000 and an annual cost of \$24,000 for this alternative. The present worth for these costs is \$300,000.

## **4.4 COMPARISON WITH FS**

No exception is taken with the plume monitoring alternative evaluation in Section 3 of the FS. However, it should be noted that the alternative water supply and institutional controls exist and need not be merely assumed to exist as done in the FS. Also, the cap is presently being installed. This makes the no-action alternative fully protective of human health and environment not just possibly protective as indicated in Section 4.2.1.2 of the FS.

### 5.1 PROCESS DESCRIPTION

Air stripping removes the organic contaminants from the ground water to the air/vapor phase. The process involves feeding the liquid to the top of an air stripping column (tower) counter current to upflowing air. The organic contaminants leave the tower with the air stream. The tower is filled with packing that provides a large surface area to enable efficient mass transfer between the two phases. Contaminants are stripped from water to the air depending on their relative volatility.

### 5.2 EVALUATION

Based on the contaminants of concern, air stripping appears to be a viable technology for treating the contaminated ground water. Air stripping is a proven and implemented technology suitable for the contaminants of concern. The American Water Works Association and studies by others show that removal efficiencies as high as 99.8 percent can be achieved by air stripping of VOCs such as vinyl chloride, TCE, toluene, benzene, and xylene which are the contaminants of concern. Therefore no further treatment of the ground water should be required. After continuous steady state operation of the air stripper and analyses of the treated ground water being discharged, a determination could be made as to whether liquid phase carbon treatment (polishing) would be necessary to remove any nonvolatile organics not yet detected in the ground water at a level of concern.

A potential disadvantage to air stripping is that pollutants are transferred to the air and therefore must be in compliance with any state or Federal air emission limits for VOCs. At this time the only identified air emission limit for the State of Minnesota is a hydrocarbon limit of 25 tons per year HC (TLV). Additional limitations are placed on HC emissions by MPCA as a matter of policy per their "Air Toxics Review Guide". Review may indicate the need for dispersion modeling and a risk assessment. The emissions estimated from the air stripper using a maximum ground water feed concentration for each organic contaminant are approximately 0.22 lb per day of total organics. This results in approximately 80 lbs per year or 0.04 tons per year which is well below the State of

Minnesota hydrocarbon limit. Therefore air treatment would not be required to comply with the 25 tons per year HC emission limit.

The FS identified short term air quality criteria in Table 2-2 which are based on a generalized MPCA air quality guideline for the approval of a new facility. Additional air dispersion modeling and a risk assessment of the emissions from the air stripper would be needed to determine potential health risk effects and compliance with the short term criteria in Table 2-2 of the FS.

If additional dispersion modeling or risk assessment calculations show the necessity for air treatment, several options exist. Vapor phase carbon could be added to the exhaust stream of the air stripper. The carbon would be effective in reducing most of the chlorinated organics but has little effectiveness for adsorbing vinyl chloride. This would not be practical since vinyl chloride is the dominant contaminant of concern. A thermal or catalytic oxidizer system could also be used. This would involve the oxidation of the organic contaminants in the gas phase using either a supplemental fuel or a catalyst, operating at lower temperatures. Lower operating temperatures used in catalytic oxidizers result in lower fuel consumption. Heat released by oxidation of the organic contaminants can be recovered to preheat gases entering the catalyst bed. This technology is developed and commercially available.

Pretreatment of the ground water may be required to prevent fouling/scaling in the stripper. Ground water inorganic analyses must be evaluated to determine whether pretreatment of inorganics will be required. High iron and manganese concentrations and high alkalinity could impact the operation and effectiveness of the air stripper by reacting with oxygen and other oxidizing chemicals, and precipitating on the tower packing. Based on the data assumed as the basis for this evaluation, the iron is at a concentration that could cause scaling problems. There are several methods to address this problem. The iron could be removed in a precipitation pretreatment step prior to feeding the air stripper. This process would involve adding chemicals such as chlorine or hydrogen peroxide to precipitate the iron and remove it before the water is fed to the air stripper. Other options for iron removal would include aeration or chemical addition and filtering using a greensand filter. The use of greensand filters is a well-established and widely used technology for removing iron and manganese. Potassium permanganate is fed upstream of the filter to oxidize the iron which is removed in the greensand filter. At the levels of iron detected in this ground water, frequent backwashing of the filter would occur. This brine stream would require

further treatment (filter press) and solids disposal. Another solution would be to add a complexing agent prior to feeding the air stripper tower. A complexing agent such as sodium hexametaphosphate would inhibit the formation of the solids and limit the amount of scaling. In addition, a routine acid washing of the tower could be helpful in removing whatever precipitation build-up does occur in the tower. However some iron oxide will precipitate in the packing, piping and infiltration pond. Iron bacteria could form and cause additional clogging problems.

Based on the data in Table 2-6 of the FS, the iron concentrations range from <1 ppm to 19.5 ppm. The actual concentration of iron from several different extraction wells will dilute this concentration and iron could be seen in the 5-15 ppm range. It is recommended to remove the iron prior to air stripping in order to prevent operational problems. The recommended method would be oxidation followed by coagulation/flocculation and filtration.

### 5.3 COST ESTIMATE

Capital and Operation and Maintenance (O&M) costs for the air stripping alternative have been estimated and are found in Tables 1A and 1B. These costs do not include the costs for ground water pretreatment for iron removal or air stripper exhaust air treatment. Pretreatment costs for iron removal are found in Table 5A/5B. Costs for air stripping with exhaust air treatment are found in Tables 2A and 2B. Costs for liquid phase carbon units for further treatment (polishing) of the ground water was not included in either case. The need for carbon would be determined after steady state operation of the system and the discharge water was analyzed. The air stripping system would be designed to meet effluents limits of less than 1 ppb for all compounds.

### 5.4 COMPARISON TO FS

#### Air Stripper

No exception is taken with regard to the air stripper considered in the FS.

### Pretreatment

The FS includes removal of inorganics by precipitation prior to stripping. This is shown in Figure 3-6 of the FS. This pretreatment is not required to meet treatment objectives for discharge to the infiltration pond but may be required to prevent problems in the packed column stripper due to iron in the water. This was not made clear in the FS but the precipitation technology proposed in the FS may have difficulty in removing iron and manganese as well as other inorganic contaminants to a level which would meet the surface water quality standards. Sometimes air can be used successfully to oxidize iron but most frequently chlorine, hydrogen peroxide, or potassium permanganate is required. Using air in this case would also drive off the volatile organics from the ground water. Therefore chemical oxidation would be more appropriate.

### Vapor Phase Treatment by GAC

The FS includes the treatment of stripper air emissions with Granular Activated Carbon (GAC). Although mentioned in the text and included in the cost, vapor phase treatment with GAC is not shown on Figure 3-6 of the FS.

GAC vapor phase control should not have been included for three reasons:

- The expected HC emission from the air stripper is below the 25 tons per year limit for the State of Minnesota.
- The VOC emissions are not likely to create a risk sufficient to require treatment per the OSWER directive for control of air emissions at superfund sites. This should be confirmed by performance of air modeling and a risk analysis.
- GAC is not very effective for removal of vinyl chloride which is the primary contaminant of concern. The contaminants which would be removed are of less concern than vinyl chloride and are present in smaller amounts.

Vapor phase treatment of organics by thermal/catalytic oxidation should be considered if modeling and the risk assessment show VOC emissions to be of significant risk. Oxidation would effectively destroy all organics including vinyl chloride.

### Effluent Polishing by GAC

A carbon contactor is included in the treatment process shown in Figure 3-6 of the FS. The purpose of the carbon contactor is to remove possible semi-volatile organics which are not removed by air stripping. The FS states that these semi-volatiles are not known to be a problem and the carbon contractor is not required to meet water quality criteria. It is included only as a "contingency for treatment of a possible variable suite of organic compounds."

The FS does not present adequate justification for including effluent polishing by GAC.



## ALTERNATIVE 3 - ADVANCED OXIDATION PROCESS

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### 6.1 PROCESS DESCRIPTION

Advanced oxidation involves contacting ozone and contaminated water in a closed reactor in the presence of ultraviolet (UV) light. The combination of UV, ozone and/or hydrogen peroxide treatment makes it possible to oxidize the organic compounds. Complete oxidation of the organics results in the formation of carbon dioxide and water. For a complex mixture complete oxidation of all contaminants may be difficult and expensive to achieve and thus a variety of low molecular weight organics could be formed in the process which would require further treatment of the water before discharge.

### 6.2 EVALUATION

Advanced oxidation systems have been used for pilot scale and full scale treatment of a variety of organic contaminants. The advantage to this treatment system is that the contaminants are destroyed in the process and there is no transfer of contaminants to the vapor phase. One drawback is that further treatment of the ground water could be necessary should undesirable organic byproducts be formed. Recent improvements in the UV oxidation process has reduced the problem of undesirable organic by products. If this method is selected it is recommended that a treatability test be performed to determine if any undesirable byproducts are formed and what concentrations could be expected. This information would then determine if further treatment, i.e., liquid phase carbon, is required. The treatability test would also indicate to what extent pretreatment of inorganic would be necessary, if at all. Inorganics such as iron at high concentrations may interfere with the oxidation process by forming an insoluble precipitate on the UV lamp surface, therefore increasing the oxidant requirements. Build-up of this material greatly reduces the effectiveness of the UV process. The iron concentrations found in Table 2-6 do not appear to be high enough to require pretreatment. Other factors such as water temperature, alkalinity, pH, hardness and flow rate influence this decision and a treatability test would be a better method on which to base this decision. There are advanced oxidation systems available with UV lamp cleaning mechanisms that can accept high concentrations of iron because they prevent build-up of scale through routine cleaning. However, iron precipitate may cause plugging problems in the infiltration pond.

### 6.3 COST ESTIMATE

Capital and Operation and Maintenance (O&M) costs for the advanced oxidation alternative are found in Tables 3A and 3B. These costs do not include water pretreatment or liquid phase carbon treatment after the oxidation step. Cost estimates in Tables 4A and 4B do include the costs for liquid phase carbon polishing.

### 6.4 COMPARISON WITH FS

#### Advanced Oxidation Process

No exception is taken to the proposed use of AOP. However, the FS does not give adequate attention to the need for treatability studies to determine whether or not pretreatment or posttreatment is required. Recent advances in AOP technology may make effluent polishing by carbon contact unnecessary.

#### Pretreatment

Pretreatment of influent to an AOP process is required where there is a problem with contaminants in the water depositing on the UV lamps. Of particular concern are iron, calcium, and magnesium. Water quality data indicates that only iron could be a problem. The levels of calcium and magnesium in the water are not sufficient to pose a problem with scaling on the UV lamps.

The AOP system presented in the FS uses lime-soda softening for pretreatment. This technology is suitable for removal of calcium. Calcium is not a concern and effective removal of iron could be accomplished by chemical oxidation and precipitation.

The necessity of pretreatment would need to be confirmed by treatability studies. AOP units are marketed which automatically clean the UV tubes. Pretreatment may not be required for such a system. Systems are in operation at sites with iron in higher concentrations than 5-15 ppm without any problem.

### Effluent Polishing by Carbon Contact

The AOP system proposed in the FS includes effluent polishing by carbon contact. This is not required to achieve performance criteria but is included for the following reasons:

- Incomplete oxidation may produce toxic organic intermediates.
- Carbon Contactors provide a low cost contingency for treatment of a possibly variable suite of organic compounds which may not be destroyed by AOP.

Recent advance in AOP systems have improved the effectiveness of the destruction of organics. It is unlikely that effluent polishing by carbon contact will be necessary. This should be confirmed by a treatability study.

## 7.1 PROCESS DESCRIPTION

Bioremediation is a technique for treating contaminated soils and ground water by using microorganisms to degrade the contaminants. The basic concept involves altering environmental conditions to enhance microbial metabolism of organic contaminants, resulting in the breakdown and detoxification of those contaminants. The environmental conditions necessary for microbial growth are optimized by providing nutrients, particularly oxygen. The process may be carried out in situ in which case the nutrients are delivered to the zone of contamination through injection wells or infiltration system. The contaminated soil or ground water may also be moved or pumped to another location (generally nearby) for treatment. Naturally occurring microorganisms can generally be relied upon to degrade a wide range of organic compounds given optimal conditions. Microorganisms specially adapted to specific organic compounds may also be added to the treatment zone.

## 7.2 EVALUATION

Treatment by bioremediation would require the introduction of nutrients into the groundwater to enhance the microbial metabolism of vinyl chloride and the other contaminants of concern. The addition of other carbon sources to serve as the primary source of carbon for microbial metabolism has been shown to enhance the cometabolism and catabolism of chlorinated hydrocarbons such as are the contaminants of concern. Bench scale testing would need to be done to determine the required types and amounts of nutrients required and to assess the effectiveness of biological degradation with respect to the MCLs for the contaminants of concern. Testing would also indicate whether or not the biodegradation would be inhibited by any inorganic compounds present in the ground water. Although not a problem with biodegradation, the high iron content of the ground water may need to be evaluated with regard to oxidation by the nutrient addition and subsequent precipitation of iron.

Treatment by bioremediation would be directed primarily to the shallow aquifer (Zone A) east of the landfill. Soils above the water table in this area are not known to be contaminated. Consequently, the addition of nutrients would not be limited to the use of an infiltration pond on the surface. Injection wells could be used to deliver the nutrients directly to contaminated zone thereby providing treatment in situ. Alternatives to in situ treatment would be to pump the contaminated plume from extraction wells, add oxygen and nutrients as required and discharge to an infiltration pond. Biological degradation would take place within and beneath the pond. Strategic location of the infiltration pond above the contaminated plume could result in some in situ bioremediation as well. The location of the extraction wells and pond or injection wells would need to be carefully chosen in order to distribute the nutrients throughout the entire plume. The FS indicates that the soils at the site are highly permeable which would enhance the performance of an infiltration pond or injection wells. An analysis of site hydraulics and physical layout would need to be performed to determine the best type of delivery system. i.e. injection wells, or infiltration pond.

Bioremediation of contaminated ground water and soils is a relatively new technology. Consequently, there is not a history of successful performance at site similar to the landfill. Considerable reliance will need to be placed on bench scale treatability studies in predicting actual performance in the field. The ability to degrade the contaminants of concern to below their MCLs may be in question.

### **7.3 COST**

A cost estimate for bioremediation was not prepared in the FS nor was an independent estimate prepared.

### **7.4 COMPARISON TO FS**

The FS did not thoroughly develop the bioremediation alternative. The FS limits consideration to an infiltration pond for nutrient addition and treatment using active down gradient controls (extraction wells). The FS appears to reject this alternative in Section 3.4.3.4 based at least in part upon the difficulty anticipated in siting the infiltration pond. The FS did not consider injection wells or infiltration pipe galleries or other possible solutions to this problem. Also, no cost estimate was prepared for this alternative.

## 8.1 REASON FOR PRETREATMENT

Pretreatment for removal of inorganic compounds in the ground water is based upon the needs of the organic treatment processes. Inorganic compounds which inhibit the removal of the organic contaminants of concern may need to be removed. No endangerment of public health or environment was shown in the RI with respect to inorganic contaminants in the ground water. The FS lists five VOCs as contaminants of concern, and also lists some inorganic compounds present in the ground water which have regulatory significance.

The focus of the treatment alternatives considered in the FS for ground water is the removal of the organic contaminants of concern. Section 3.1 of the FS stated "Removal of inorganic compounds may not be required, depending on actual inorganic concentration in pumped ground water." Table 2-3 of the FS presents the applicable or relevant and appropriate requirements (ARARs) for inorganics. The concentrations of inorganics expected in the ground water pumped for treatment shown in Table 3-5 of the FS do not exceed the ARARs except for iron and manganese which are secondary (not health based) standards and are not enforceable. Therefore, treatment for removal of inorganics solely for health based reasons is not required.

## 8.2 PROCESS DESCRIPTION

### 8.2.1 Iron Precipitation

Precipitation is the process of making dissolved chemical constituents insoluble so that they can be separated from the liquid. Precipitation is usually accomplished by adding a chemical or adjusting the pH to form an insoluble compound with the target contaminant. Iron and manganese are readily oxidized to form an insoluble precipitate. The precipitates are often coagulated and flocculated into larger particles with the help of coagulants prior to solids removal by sedimentation and filtration. Iron removal frequently starts with

oxidation of the water with oxygen, chlorine, or potassium permanganate. This method of treatment is relatively ineffective for dissolved inorganics other than iron and manganese.

Iron and manganese in high concentrations can react with oxygen and other oxidizing chemicals to form precipitates thus interfering with the organic treatment process. This precipitate could form coatings on air stripper tower packing and on the internals of the UV/oxidation equipment. This material could cause severe problems in piping systems treatment equipment and the infiltration pond.

Discussions with vendors and users of air strippers indicate that it is necessary to remove iron and manganese if found in high concentrations. UV/oxidation system vendors indicate that they can handle moderate levels of iron and manganese depending on other conditions and parameters such as pH, temperature, alkalinity and flow rate. Iron does exist in the ground water at the site in concentrations high enough to warrant pretreatment to prevent precipitate formation and scaling in the air stripping system. Manganese does not appear to present a problem. A treatability test would provide information on the extent, if any, of pretreatment required for the AOP system

### **8.2.2 Lime Soda Softening**

Lime soda softening is a precipitation process that reduces the hardness of water by the application of hydrated lime to water to precipitate  $\text{CaCO}_3$ ,  $\text{Mg}(\text{OH})_2$  or both. The hydroxyl radical converts  $\text{CO}_2$  and  $\text{HCO}_3^-$  (bicarbonate) to carbonate ( $\text{CO}_3^{2-}$ ) causing  $\text{CaCO}_3$  to precipitate. Other hydroxide compounds (NaOH, KOH) could be used but lime is usually lower in cost than the other compounds. The precipitated compounds are removed by sedimentation. Besides precipitating calcium and magnesium, lime-soda softening will also precipitate other inorganic compounds including iron, manganese, arsenic, nickel and barium.

Calcium and magnesium can cause scaling problems in either organic treatment system, ie. air stripping or the advanced oxidation process. Lime-soda softening will remove the calcium and magnesium as well as iron, manganese and other inorganic compounds. Lime-soda softening is a more complex operation and produces much more sludge than iron precipitation. Furthermore, the sludge may contain hazardous inorganic compounds such as arsenic which are removed from the water. The presence of these compounds may

render the sludge hazardous resulting in increased disposal costs. Hazardous inorganics may also be removed by iron precipitation due to adsorption; however, it would be much less than what would be removed by lime-soda softening. Consequently, lime-soda softening should not be used in this case where calcium and magnesium are not a problem.

### **8.3 COST ESTIMATE**

Capital and Operation and Maintenance (O&M) costs for the precipitation step are found in Tables 5A and 5B. These costs are provided for comparison with the EPA selected remedy and not because lime-soda softening is recommended by this evaluation.

### **8.4 COMPARISON TO FS**

#### **8.4.1 Reason for Pretreatment**

The FS initially considers pretreatment for removal of inorganics only with respect to the requirements for treatment of the organic contaminants of concern. Some inorganics might tend to inhibit the organic treatment processes and would need to be removed. However, this focus was lost when in Section 3.4.2 the following statement was made by the EPA with respect to inorganics treatment alternatives: "Conceptual designs are primarily based on barium as this compound is present at concentrations that sometimes exceed current drinking water standards." This statement is confusing and unsupported for the following reasons:

- No risk analysis was ever performed with respect to barium.
- The RI does not mention barium as a contaminant of concern. Only five organic compounds were identified as contaminants of concern requiring treatment.
- The FS does not show barium to be above its MCL in the ground water pumped for treatment.
- The inorganics treatment proposed in the FS for the air stripping alternative may not give a significant reduction in the level of barium.



Coagulation/flocculation was proposed which will not appreciably remove insoluble inorganics such as barium.

The misplaced focus on barium continues in the ROD where on page 12 the only reason given for lime-soda softening pretreatment of ground water ahead of AOP treatment is for the removal of barium. Pretreatment requirements associated with the AOP process are not mentioned in the ROD.

#### **8.4.2 Iron Precipitation**

The precipitation process described in the FS in conjunction with chemical oxidation would provide adequate treatment for removal of iron and manganese prior to treatment by air stripping or AOP. However, it was proposed only for pretreatment at the air stripper. The FS does not describe the oxidation step which would be required to convert soluble iron and manganese to an insoluble precipitate. Coagulation and flocculation will remove these insoluble precipitates but will have little effect on the insoluble inorganic contaminants. The FS states in Section 3.4.2.1 that soluble ions [such as barium] may be only partially removed by adsorption on the floc.

#### **8.4.3 Lime-Soda Softening**

The lime-soda softening process will not only reduce the hardness of the water which could cause scaling problems in AOP or air stripping processes but also would remove iron, nickel, arsenic and barium as a result of the elevation of the pH during the process. However, alkalinity reduction and iron removal are the only concerns specified by the EPA in the FS with regard to pretreatment required for organics removal.

Lime-soda softening was chosen by the FS for pretreatment for the AOP system. The FS states in Section 3.4.2.2 that the advantages of lime-soda softening over precipitation are:

- "- chemical additions are less costly
- alkalinity is removed, which improves the effectiveness of organics by AOP treatment."

The first advantage is not shown by the costs presented in Tables 3-5 and 3-7 of the FS. The present worth of the lime-soda softening system is shown to be \$2,900,000 vs. \$2,200,000 for precipitation. The second advantage given is true to the extent that alkalinity is removed. Whether or not the effectiveness of organics removed by AOP will be increased enough to justify the additional expenditure for lime-soda softening is questionable. Water quality data contained in the RI indicates that alkalinity may not be a problem.

## **8.5 CONCLUSION**

It is noted that the FS selected precipitation for pretreatment with air stripping and lime-soda softening with AOP. The additional expense of using lime-soda softening with AOP does not appear to be warranted. Precipitation is suitable for both processes. The lime-soda softening process will remove calcium and magnesium which were not demonstrated to be a problem in the FS. This will produce an unnecessarily high volume of sludge to be disposed of. This sludge may be considered hazardous since minute amounts of some inorganic compounds such as arsenic present in the ground water will be removed and concentrated in the sludge possibly rendering it hazardous. The cost estimate in the FS did not price the disposal of hazardous sludge.

## OTHER POTENTIAL ALTERNATIVES - STEAM STRIPPING

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### 9.1 PROCESS DESCRIPTION

Steam stripping involves stripping contaminants from feed water with steam in a vacuum stripper. The steam-organic vapors are then condensed, and the resulting aqueous and organic phases separated. The aqueous phase is recycled back to the process.

Vacuum steam stripping technology is capable of obtaining very low effluent concentrations with minimum energy consumption. Effluent water qualities in the 1-1.5  $\mu\text{g/L}$  range can be obtained for over 80 percent of the priority pollutants. This process is also effective for stripping compounds with low volatiles and high boiling points. The process does not work well with organics which are highly soluble in water as it is dependent upon a liquid/liquid phase separation.

### 9.2 EVALUATION

Steam stripping is a well demonstrated technology and commonly used in industry. As compared to air stripping, it may be used to treat less volatile compounds. However, the process generates a concentrate that requires treatment or disposal if recycling of the concentrate is not an option. Steam stripping does not appear to be a viable alternative to air stripping or AOP at the Kummer Landfill site due to high costs and the volatility of the contaminants of concern.

### 9.3 COST ESTIMATE

This process is expensive to operate and is usually only effective when a source of waste heat or low cost fuel for producing steam is available.

10.0

EVALUATION OF ALTERNATIVES

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### 10.1 BASIS OF EVALUATION

Remedial alternative were developed in the FS based upon the following response categories:

- hydraulic controls
- ground water treatment
- effluent management

This evaluation considers only the ground water treatment alternatives. Alternatives were evaluated and screened per EPA guidelines with respect to the following:

- effectiveness
- technical feasibility and implementability
- adverse effects on the environment
- cost

Alternatives which passed the screening analysis were analyzed in detail using nine evaluation criteria developed by EPA to address the requirements and considerations for appropriate remedial action at CERCLA sites. The nine criteria address the following concerns.

1. Overall Protection of Human Health and the Environment - addresses whether or not the remedy provides adequate protection and describes how risks are eliminated, reduced or controlled through treatment, engineering controls, or institutional controls.
2. Compliance with ARARs - addresses whether or not the remedy will meet all of the applicable or relevant and appropriate requirements of other environmental statutes and/or provide grounds for invoking a waiver.

3. Long-term Effectiveness - and permanence refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup goals have been met.
4. Reduction of Toxicity, Mobility, or Volume - refers to the anticipated performance of the treatment technologies a remedy may employ.
5. Short-term Effectiveness - involves the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.
6. Implementability - refers to the technical and administrative feasibility of a remedy, including the availability of goods and services needed to implement the chosen solution.
7. Cost - includes capital and operation and maintenance costs.
8. Regulatory Agency Acceptance - indicates whether the regulatory agencies (MPCA and EPA) concur, oppose, or have no comment on the preferred alternative.
9. Community Acceptance - indicates the public support of a given remedy.

The FS followed the requirements of the EPA guidance documents in their approach to the development and evaluation of alternatives. The following section describes possible faults in the FS with respect to the screening and analysis of alternatives.

## 10.2 SCREENING OF ALTERNATIVES

Four technologies were considered for treatment of the contaminants of concern in the ground water:

- air stripping
- advanced oxidation process (AOP)
- discharge to a publicly owned treatment works (POTW)
- bioremediation

These technologies were summarized and evaluated in Section 3.4.1 of the FS. Table 3-8 of the FS presents a screening summary of the alternatives. Bioremediation was not included in Table 3-8 and no reasons were given for its omission. The summary table also errors in statements made regarding inorganics treatment for the air stripping alternative. Table 3-8 and Section 3.4.3.1 of the FS both speak of transfer of contaminants to land disposal in sludge which results from pretreatment for inorganics removal prior to air stripping. However, Section 3.4.2.1 mentions only a possible partial removal of some solubilized ions including barium, nickel and arsenic by adsorption. It is questionable that significant removal of these inorganics by adsorption would occur and that it would be sufficient to render the sludge hazardous. The possibility of a hazardous sludge by-product does exist with the lime-soda softening process proposed as pretreatment for the AOP system because it would effectively remove inorganics such as barium, nickel and arsenic.

Besides not being included in Table 3-8, the bioremediation alternative does not get the same treatment in the text as do the other alternatives. Bioremediation is not seriously developed as an alternative and a cost estimate was not even prepared. Section 3.4.1.4 of the FS appears to reject this alternative based upon possible difficulty in locating an appropriate location for the recharge pond and the alleged inability to biologically degrade vinyl chloride to surface water quality standards. However, no mention was made of possible in situ methods for nutrient addition which would eliminate the need for a recharge pond such as injection wells. Vinyl chloride does degrade naturally. A treatability study would be required to determine if treatment goals could be reached using bioremediation. The statement that bioremediation would not be effective is not supported.

The screening analysis performed in the FS resulted in the carrying forward of only one technology for treatment of the ground water, AOP. Discharge to a POTW was shown on Table 3-8 to be not feasible. However, no reason is given nor is apparent for rejecting air stripping and bioremediation from further consideration.

### **10.3 ANALYSIS OF ALTERNATIVES**

Based on screening results discussed above, three alternatives were carried forward in the FS for detailed evaluation:

- Alternative I - No further action or limited action with non-point source discharge to Lake Bemidji.

- Alternative II - Active downgradient controls, on-site treatment by AOP and lime soda softening, and point source discharge to Lake Bemidji.
- Alternative III - Active downgradient controls, on-site treatment by AOP, possible on-site treatment by lime soda softening, and on-site disposal in an infiltration pond.

Besides the lack of an analysis for air stripping and bioremediation, the shortcomings of the analysis mainly involve Alternative I. Comments made with regard to the analysis of this alternative are not consistent throughout the FS and several conclusions are simply incorrect.

The FS considers Alternative I to be "likely protective" of human health and the environment. The ROD contradicts the FS by stating that it is "not protective". These statements made in the ROD are not supported by the material presented in the FS. Modeling results in the FS show that Alternative I is protective of the environment at Lake Bemidji while the alternate water supply and institutional controls remove the risk of exposing humans to the ground water. A finding of "protective" would have been correct and is supported by the FS.

The FS states that Alternative I does not meet ARARs with respect to the EPA ground water protection strategy. Placing the EPA ground water protection strategy on equal standing with promulgated regulations is questionable at best. EPA guidelines allow a waiver of ARARs under certain conditions. Section 6.2.3.2 of the EPA Guidance for Conducting Remedial Investigations/Feasibility Studies under CERCLA (EPA 540/G-89/004 Oct. 1988) states: "When an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA should be discussed." Section 1.3.1.1. allows a waiver of ARARs under six different circumstances, two of which apply to this site:

- The remedial action selected is only a part of total remedial action (interim remedy) and the final remedy will attain the ARAR upon its completion.
- An alternative remedial action will attain an equivalent standard or performance through the use of another method or approach.

The FS did not consider the waivers allowed by the guidance document and did not present the fact that another part of the total remedy, the alternate water supply, provides an alternative to ground water treatment whereby Alternative I attains a standard of performance that is equivalent to a ground water supply of drinking water quality. Waiver of the requirement to restore the ground water to drinking water quality was justified in accordance with EPA guidelines. Also, ground water modeling performed in the FS showed that surface water quality standards would not be exceeded with Alternative I. Since the FS shows Alternative I does meet surface water quality ARARs and ground water quality ARARs can be satisfied through use of a waiver, Alternative I does comply with the ARARs.

Table 4-1 of the FS summarizes the evaluation of Alternative I. It describes Alternative I as "effective" with regard to long term effectiveness. Table 4-4 provides a summary comparison between the different alternatives with respect to the evaluation criteria. It calls Alternative I only "probably effective." Ground water modeling indicated long term effectiveness with regard to the discharge to Lake Bemidji. In addition, Alternative I is effective with regard to short term risks as stated in the text of the FS. However, Table 4-1 calls it "probably ineffective" and Table 4-4 calls it "probably effective." Table 4-4 is essential in the final selection process. Consequently these errors in Table 4-4 render the conclusions reached through its use invalid. These errors resulted in at best a final evaluation by EPA that had unwarranted bias against the selection of Alternative I as the remedy for operable unit three.

Ground water modeling in the FS predicted that 60% of the contaminant plume would be captured within the first four years of the operation of a pump and treat system. Cost estimates for Alternative III with the AOP treatment system were calculated in the FS to be from 3.0 to 6.2 million dollars based on an operating period of 4 to 30 years. The costing assumption was premised on remediation possibly being complete and the pumps turned off some time after four years. Such an early cessation of pumping is unlikely. Similar systems generally experience considerable delays in getting approval to stop treatment. The FS also appears to have underestimated the capital and operating costs. A present worth estimate of 11.5 million dollars for construction and 30 years of operation would be more realistic (based on Cost Tables 3A, 3B, 5A and 5C plus FS cost estimate for carbon treatment and down gradient controls). The cost estimate in the FS is unrealistically low, particularly at the bottom end of the range given.



Modeling of Alternative I in the FS indicated that the ground water would naturally return to usable drinking water after 80 years. Consequently, the long term effect of Alternative I will be the restoration of the ground water supply to drinking water quality. The long term effectiveness of all the alternatives depends a great deal on the effectiveness of the landfill cover in reducing infiltration. If the cover is not sufficiently effective to allow the ground water quality to be restored under Alternative I, then it will also not be possible to turn off the pumps in Alternatives II or III causing an increase in costs.

The modeling performed in the FS assumed a 75 percent reduction in leachate due to the cover. Landfill covers which will reject in excess of 90 percent of rainfall have been commonly constructed and used for several years. Further analysis might be warranted to determine the possible impact of alternative cover designs on the long term ground water quality.

#### 10.4 CONCLUSION

An examination of Alternative I (plume monitoring) for operable unit no. 3, ground water, shows it to fully meet the remedial objectives identified in the FS. Those objectives given in Section 2 of the FS are to provide a safe drinking water supply down-gradient of the landfill and to prevent significant impact on the surface water quality at Lake Bemidji. Data from the risk analysis performed in the RI indicates human health risk may quite possibly be less than  $10^{-4}$  without any action. The provision of an alternate water supply (operable unit one) to residences down-gradient of the landfill plus the well advisory issued by the MDH assures the virtual elimination of any risk to human health. Ground water modeling performed in the FS demonstrated that the landfill cover (operable unit two) presently under construction will protect the water quality of Lake Bemidji from any significant impacts. Besides being fully protective of human health and the environment, the plume monitoring alternative complies with the ARARs via operable unit one. Long term protection is provided by the alternate water supply and institutional controls. Section 3.3.1 of the FS states that modeling results also indicate that plume monitoring appears to achieve the ground water remedial action objective of preventing significant contaminant migration to shallow ground water down gradient of the landfill due to the landfill cover being implemented under operable unit 2. A comparison of alternatives shows that plume monitoring is just as effective as the other alternatives in achieving these goals but at a much lower cost. Therefore, based on these criteria, plume monitoring is the most appropriate remedy.

**TABLES**

**COST**

TABLE 1A  
CAPITAL COST FOR AIR STRIPPING SYSTEM

MAJOR PURCHASE EQUIPMENT (MPE)		COST
-----		-----
1)	Air Stripper Tower and Packing w/Air blowers(100 gpm)	\$35,000
2)	Transfer Pumps (100 GPM) 2 @ \$2,000.00 ea.	\$4,000
3)	Holding Tank(10,000 gallon)	\$15,000
		-----
SUBTOTAL - MPE		\$54,000
DIRECT COSTS (DC)		
-----		
ITEM	DESCRIPTION	COST
-----		-----
1)	Major Purchased Equipment (MPE)	\$54,000
2)	Purchase Equipment Installation @ 15% of MPE (Includes Labor, and Equipment for Installation)	\$8,100
3)	Instrumentation and Controls @ 15% of MPE	\$8,100
4)	Piping (Installed) @ 10% of MPE	\$5,400
5)	Electrical (Installed) @ 15% of MPE	\$8,100
6)	Buildings (including Services) @ 50% of MPE	\$27,000
7)	Site Preparation @ 5% of MPE	\$2,700
8)	Service Facilities @ 12% of MPE	\$6,480
		-----
DIRECT COST (DC):		\$119,880
INDIRECT COSTS		
-----		
9)	Engineering and Supervision @ 20% of DC	\$23,976
10)	Construction Expenses @ 10% of DC	\$11,988
		-----
INDIRECT COST (IC)		\$35,964
SUBTOTAL (DC+IC):		\$155,844
11)	Contingency @ 20% of Subtotal of DC & IC	\$31,169
		-----
TOTAL CAPITAL REQUIREMENT:		\$187,013
		=====

TABLE 1B  
ANNUAL OPERATION & MAINTENANCE COSTS - AIR STRIPPER

ITEM	DESCRIPTION	COST
<b>A. DIRECT PRODUCTION -</b>		
1) Raw Materials :	Packing Changes \$1,500/2yrs.	\$750
2) Operating Labor :	20hrs/wk @ \$23/hr X 52wks/yr.	\$23,920
3) Direct Supervision :	\$45/hr @ 364hrs./yr. (7 hrs/wk)	\$16,380
4) Utilities :	Electricity 250kwh/day @ \$.08/kwh	\$7,300
5) Maintenance & Repairs:	10% of Capital (direct costs)	\$11,988
6) Operating Supplies :	10% of Maintenance & Repair	\$1,199
7) Estimated Sampling & Laboratory Charges -		
	Air Stripper Performance Monitoring :	
	Air Sampling / Sampling Analysis	\$12,000
	Water Sampling / Sampling Analysis	\$12,000
	Sampling Operations	\$2,500
	Aquifer Performance Monitoring:	
	Sampling Analysis	\$13,000
	Sampling Operations	\$10,000
	Sampling Validation and Reporting:	\$5,000
	SUBTOTAL SAMPLING:	\$54,500
	TOTAL DIRECT PRODUCTION COST:	\$116,037
<b>B. FIXED CHARGES -</b>		
1) Depreciation @ 5% of Total Capital Requirement		\$9,351
2) Local Taxes @ .2% of Total Capital Requirement		\$374
3) Insurance @ .7% of Total Capital Requirement		\$1,309
	SUBTOTAL FIXED CHARGES:	\$11,034
<b>C. PLANT OVERHEAD -</b>		
	Calculated @ 15% of Labor, Supervision, Maintenance & Repairs (includes up-keep of system, health and safety and misc. maintenance):	\$7,843
<b>D. DISPOSAL COSTS -</b>		
	Packing Disposal (Assume Non-hazardous):	\$100
	SUBTOTAL (Items A+B+C+D):	\$135,014
	CONTINGENCY @ 20%	\$27,003
	TOTAL ANNUAL OPERATIONS AND MAINTENANCE COSTS:	\$162,017

TABLE 2A  
CAPITAL COST FOR AIR STRIPPING SYSTEM  
WITH OXIDIZER

MAJOR PURCHASE EQUIPMENT (MPE)		COST
-----		-----
1)	Air Stripper Tower and Packing w/Air blowers(100gpm)	\$35,000
2)	Transfer Pumps (100 GPM) 2 @ \$2,000.00 ea.	\$4,000
3)	Catalytic Thermal Oxidizer	\$86,000
4)	Holding Tank(10,000 gallon)	\$15,000
		-----
SUBTOTAL - MPE		\$140,000

DIRECT COSTS (DC)

ITEM	DESCRIPTION	COST
-----		-----
1)	Major Purchased Equipment (MPE)	\$140,000
2)	Purchase Equipment Installation @ 10% of MPE (Includes Labor, and Equipment for Installation)	\$14,000
3)	Instrumentation and Controls @ 15% of MPE	\$21,000
4)	Piping (Installed) @ 10% of MPE	\$14,000
5)	Electrical (Installed) @ 15% of MPE	\$21,000
6)	Buildings (including Services) @ 40% of MPE	\$56,000
7)	Site Preparation @ 5% of MPE	\$7,000
8)	Service Facilities @ 12% of MPE	\$16,800
		-----
DIRECT COST (DC):		\$289,800

INDIRECT COSTS

9)	Engineering and Supervision @ 20% of DC	\$57,960
10)	Construction Expenses @ 10% of DC	\$28,980
		-----
INDIRECT COST (IC)		\$86,940
SUBTOTAL (DC+IC):		\$376,740
11)	Contingency @ 20% of Subtotal of DC & IC	\$75,348
		-----
TOTAL CAPITAL REQUIREMENT:		\$452,088
		=====

TABLE 2B  
ANNUAL OPERATION & MAINTENANCE COSTS - AIR STRIPPER WITH OXIDIZER

ITEM	DESCRIPTION	COST
<b>A. DIRECT PRODUCTION -</b>		
1) Raw Materials :	Packing Changes \$1,500/2yrs.	\$750
2) Operating Labor :	20hrs/wk @ \$23/hr X 52wks/yr.	\$23,920
3) Direct Supervision :	\$45/hr @ 364hrs./yr. (7 hrs/wk)	\$16,380
4) Utilities :	Electricity 250kwh/day @ \$.08/kwh	\$7,300
5) Maintenance & Repairs:	10% of Capital (direct costs)	\$28,980
6) Operating Supplies :	10% of Maintenance & Repair	\$2,898
7) Estimated Sampling & Laboratory Charges -		
	Air Stripper Performance Monitoring :	
	Air Sampling / Sampling Analysis	\$12,000
	Water Sampling / Sampling Analysis	\$12,000
	Sampling Operations	\$2,500
	Aquifer Performance Monitoring:	
	Sampling Analysis	\$13,000
	Sampling Operations	\$10,000
	Sampling Validation and Reporting:	\$5,000
		-----
	SUBTOTAL SAMPLING:	\$54,500
		-----
	TOTAL DIRECT PRODUCTION COST:	\$134,728
<b>B. FIXED CHARGES -</b>		
1) Depreciation @ 5% of Total Capital Requirement		\$22,604
2) Local Taxes @ .2% of Total Capital Requirement		\$904
3) Insurance @ .7% of Total Capital Requirement		\$3,164
		-----
	SUBTOTAL FIXED CHARGES:	\$26,672
<b>C. PLANT OVERHEAD -</b>		
	Calculated @ 15% of Labor, Supervision, Maintenance & Repairs (includes up-keep of system, health and safety and misc. maintenance):	\$10,392
<b>D. DISPOSAL COSTS -</b>		
	Packing Disposal (Assume Non-hazardous):	\$100
		-----
	SUBTOTAL (Items A+B+C+D):	\$171,892
	CONTINGENCY @ 20%	\$34,378
		-----
	TOTAL ANNUAL OPERATIONS AND MAINTENANCE COSTS:	\$206,270
		=====

TABLE 3A  
CAPITAL COST FOR UV OXIDATION

MAJOR PURCHASE EQUIPMENT (MPE)		COST
-----		-----
1)	Oxidation Reactor and Associated Equipment(100 gpm)	\$235,000
2)	Transfer Pumps (100 GPM) 2 @ \$2000.00 ea.	\$4,000
3)	Holding Tank (10,000 gallon)	\$15,000
		-----
SUBTOTAL - MPE		\$254,000
DIRECT COSTS (DC)		
-----		
ITEM	DESCRIPTION	COST
-----		-----
1)	Major Purchased Equipment (MPE)	\$254,000
2)	Purchase Equipment Installation @ 15% of MPE (Includes Labor, and Equipment for Installation)	\$38,100
3)	Instrumentation and Controls @ 15% of MPE	\$38,100
4)	Piping (Installed) @ 10% of MPE	\$25,400
5)	Electrical (Installed) @ 15% of MPE	\$38,100
6)	Buildings (including Services) @ 30% of MPE	\$76,200
7)	Site Preparation @ 5% of MPE	\$12,700
8)	Service Facilities @ 12% of MPE	\$30,480
		-----
DIRECT COST (DC):		\$513,080
INDIRECT COSTS		
-----		
9)	Engineering and Supervision @ 15% of DC	\$76,962
10)	Construction Expenses @ 15% of DC	\$76,962
		-----
INDIRECT COST (IC)		\$153,924
		-----
SUBTOTAL (DC+IC):		\$667,004
11)	Contingency @ 20% of Subtotal of DC & IC	\$133,401
		-----
TOTAL CAPITAL REQUIREMENT:		\$800,405
		=====

TABLE 3B  
ANNUAL OPERATION & MAINTENANCE COSTS - UV OXIDE

ITEM	DESCRIPTION	COST
A.	DIRECT PRODUCTION -	
1)	Raw Materials : Hydrogen peroxide & lamp replacement in utility operating cost	\$0
2)	Operating Labor : 20hrs/wk @ \$23/hr X 52wks/yr.	\$23,920
3)	Direct Supervision : \$45/hr @364hrs./yr.(7 hrs/wk)	\$16,380
4)	Utilities : Electricity/Operating Cost @ \$1.75 per 1000 gallons	\$91,980
5)	Maintenance & Repairs: 5% of Capital(Direct Cost)	\$25,654
6)	Operating Supplies : Included in Operating Costs	\$0
7)	Estimated Sampling & Laboratory Charges -	
	Performance Monitoring :	
	Air Sampling / Sampling Analysis	\$12,000
	Water Sampling / Sampling Analysis	\$12,000
	Sampling Operations	\$2,500
	Aquifer Performance Monitoring:	
	Sampling Analysis	\$13,000
	Sampling Operations	\$10,000
	Sampling Validation and Reporting:	\$5,000
	SUBTOTAL SAMPLING:	\$54,500
	TOTAL DIRECT PRODUCTION COST:	\$212,434
B.	FIXED CHARGES -	
1)	Depreciation @ 5% of Total Capital Requirement	\$40,020
2)	Local Taxes @ .2% of Total Capital Requirement	\$1,600
3)	Insurance @ .7% of Total Capital Requirement	\$5,603
	SUBTOTAL FIXED CHARGES:	\$47,223
C.	PLANT OVERHEAD -	
	Calculated @ 5% of Labor, Supervision, Maintenance & Repairs (includes up-keep of system, health and safety and misc. maintenance):	\$3,298
D.	DISPOSAL COSTS -20 container(lamps)/yr @ \$300/container	\$6,000
	SUBTOTAL (Items A+B+C+D):	\$268,955
	CONTINGENCY @ 20%	\$53,791
	TOTAL ANNUAL OPERATIONS AND MAINTENANCE COSTS:	\$322,746



TABLE 4A  
CAPITAL COST FOR UV OXIDATION WITH CARBON POLISHING

MAJOR PURCHASE EQUIPMENT (MPE)		COST
-----		-----
1)	Oxidation Reactor and Associated Equipment	\$235,000
2)	Transfer Pumps (250 GPM) 2 @ \$2000.00 ea.	\$4,000
3)	Holding Tank (10,000 gallon)	\$15,000
4)	Liquid Phase Carbon Polishing(100gpm)	\$22,500
		-----
SUBTOTAL - MPE		\$276,500
DIRECT COSTS (DC)		
-----		
ITEM	DESCRIPTION	COST
-----		-----
1)	Major Purchased Equipment (MPE)	\$276,500
2)	Purchase Equipment Installation @ 15% of MPE (Includes Labor, and Equipment for Installation)	\$41,475
3)	Instrumentation and Controls @ 15% of MPE	\$41,475
4)	Piping (Installed) @ 10% of MPE	\$27,650
5)	Electrical (Installed) @ 15% of MPE	\$41,475
6)	Buildings (including Services) @ 30% of MPE	\$82,950
7)	Site Preparation @ 5% of MPE	\$13,825
8)	Service Facilities @ 12% of MPE	\$33,180
		-----
DIRECT COST (DC):		\$558,530
INDIRECT COSTS		
-----		
9)	Engineering and Supervision @ 20% of DC	\$111,706
10)	Construction Expenses @ 15% of DC	\$83,780
		-----
INDIRECT COST (IC)		\$195,486
		-----
SUBTOTAL (DC+IC):		\$754,016
11)	Contingency @ 20% of Subtotal of DC & IC	\$150,803
		-----
TOTAL CAPITAL REQUIREMENT:		\$904,819
		=====

TABLE 4B  
ANNUAL OPERATION & MAINTENANCE COSTS - UV OXIDE & GAC POLISHING

ITEM	DESCRIPTION	COST
<b>A.</b>	<b>DIRECT PRODUCTION -</b>	
1)	Raw Materials : Carbon:4 changes of 8000lbs @ \$0.45/lb Hydrogen Peroxide & lamp replacement included in operating cost	\$14,400 \$0
2)	Operating Labor : 20hrs/wk @ \$23/hr X 52wks/yr.	\$23,920
3)	Direct Supervision : \$45/hr @ 364hrs./yr. (7hrs./wk)	\$16,380
4)	Utilities :Electricity/Operating Cost @\$1.75per 1000gal	\$25,654
5)	Maintenance & Repairs: 5% of Capital (Direct Cost)	\$27,926
6)	Operating Supplies : Included in Service Contract	\$0
7)	Sampling & Laboratory Charges -	
	Performance Monitoring :	
	Air Sampling / Sampling Analysis	\$12,000
	Water Sampling / Sampling Analysis	\$12,000
	Sampling Operations	\$2,500
	Aquifer Performance Monitoring:	
	Sampling Analysis	\$13,000
	Sampling Operations	\$10,000
	Sampling Validation and Reporting:	\$5,000
	<b>SUBTOTAL SAMPLING:</b>	<b>\$54,500</b>
	<b>TOTAL DIRECT PRODUCTION COST:</b>	<b>\$162,780</b>
<b>B.</b>	<b>FIXED CHARGES -</b>	
1)	Depreciation @ 5% of Total Capital Requirement	\$45,240
2)	Local Taxes @ .2% of Total Capital Requirement	\$1,809
3)	Insurance @ .7% of Total Capital Requirement	\$6,333
	<b>SUBTOTAL FIXED CHARGES:</b>	<b>\$53,382</b>
<b>C.</b>	<b>PLANT OVERHEAD -</b>	
	Calculated @ 5% of Labor, Supervision, Maintenance & Repairs (includes up-keep of system, health and safety and misc. maintenance):	\$3,411
<b>D.</b>	<b>DISPOSAL COSTS -20 drums(lamps)/yr @ \$300/drum</b>	<b>\$6,000</b>
<b>E.</b>	<b>Carbon Replacement Freight (\$ 0.70 per lb.) 32000 lb.</b>	<b>22400</b>
	<b>SUBTOTAL (Items A+B+C+D):</b>	<b>\$247,973</b>
	<b>CONTINGENCY @ 20%</b>	<b>\$49,595</b>
	<b>TOTAL ANNUAL OPERATIONS AND MAINTENANCE COSTS:</b>	<b>\$297,568</b>

TABLE 5A.1  
CAPITAL COST FOR PRECIPITATION

ITEM	MAJOR PURCHASE EQUIPMENT (MPE)	COST
	-----	-----
1)	Collection tank, nominal capacity 5000 gallons	\$5,000
2)	Transfer Pumps (8): Capacity 100 GPM	\$12,600
3)	Inclined plate clarifier	\$70,000
4)	Sludge pumps(4): Double diaphragm 60 gpm capacity and Skimmer pumps (2)@50 gpm each	\$10,000
5)	Filters: Mixed media	\$4,000
6)	Discharge tank with mixer, nominal 1,500 gallon capacity with 4 hp mixer	\$2,600
7)	Sludge collection tank: nominal capacity 3,000 gallons	\$3,000
8)	Filter press: plate and frame type	\$50,000
9)	Chemical storage and tanks (3); nominal 500 gallon capacity/ one tank with 2 hp mixer	\$2,800
10)	Chemical metering pumps (4) including 1 spare	\$3,000
		-----
	SUBTOTAL - MPE	\$163,000

TABLE 5A.2  
DIRECT COSTS (DC)

ITEM	DESCRIPTION	COST
1)	Major Purchased Equipment (MPE)	\$163,000
2)	Purchase Equipment Installation @ 15% of MPE (Includes Labor, and Equipment for Installation)	\$24,450
3)	Instrumentation and Controls @ 15% of MPE	\$24,450
4)	Piping (Installed) @ 10% of MPE	\$16,300
5)	Electrical (Installed) @ 15% of MPE	\$24,450
6)	Buildings (including Services) @ 30% of MPE	\$48,900
7)	Site Preparation @ 5% of MPE	\$8,150
8)	Service Facilities @ 12% of MPE	\$19,560
DIRECT COST (DC):		\$329,260
INDIRECT COSTS		
9)	Engineering and Supervision @ 15% of DC	\$49,389
10)	Construction Expenses @ 15% of DC	\$49,389
INDIRECT COST (IC)		\$98,778
SUBTOTAL (DC+IC):		\$428,038
11)	Contingency @ 20% of Subtotal of DC & IC	\$85,608
TOTAL CAPITAL REQUIREMENT:		\$513,646

**TABLE 5B**  
**ANNUAL OPERATION & MAINTENANCE COSTS - Precipitation**  
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ITEM	DESCRIPTION	COST
<b>A.</b>	<b>DIRECT PRODUCTION -</b>	
1)	Raw Materials : Chemicals: Assume potassium permanganate @ 4,000 lbs @ \$ .39/lb	\$1,560
2)	Operating Labor : 12hrs/wk @ \$23/hr X 52wks/yr.	\$167,440
3)	Direct Supervision : \$45/hr @ 2080hrs./yr.	\$93,600
4)	Utilities : Electricity 170kwh/day @ \$.08/kwh	\$4,964
5)	Maintenance & Repairs: 10% of Capital (direct costs)	\$32,926
6)	Operating Supplies : 10% of Maintenance & Repair	\$3,293
7)	Sampling & Laboratory Charges -	
	Performance Monitoring :	
	Water Sampling / Sampling Analysis	\$12,000
	Sampling Operations	\$2,500
	Sampling Validation and Reporting:	\$5,000
		-----
	SUBTOTAL SAMPLING:	\$19,500
		-----
	TOTAL DIRECT PRODUCTION COST:	\$323,283
<b>B.</b>	<b>FIXED CHARGES -</b>	
1)	Depreciation @ 5% of Total Capital Requirement	\$25,682
2)	Local Taxes @ .2% of Total Capital Requirement	\$1,027
3)	Insurance @ .7% of Total Capital Requirement	\$3,595
		-----
	SUBTOTAL FIXED CHARGES:	\$30,304
<b>C.</b>	<b>PLANT OVERHEAD -</b>	
	Calculated @ 15% of Labor, Supervision, Maintenance & Repairs (includes up-keep of system, health and safety and misc. maintenance):	\$44,095
<b>D.</b>	<b>DISPOSAL COSTS -</b>	
	Solids-(Assume disposal as hazardous)	
	6 cuyd @ \$200/cuyd	\$1,200
		-----
	SUBTOTAL (Items A+B+C+D):	\$398,882
	CONTINGENCY @ 20%	\$79,776
		-----
	TOTAL ANNUAL OPERATIONS AND MAINTENANCE COSTS:	\$478,658
		=====

TABLE 5C  
ANNUAL OPERATION & MAINTENANCE COSTS - Lime-Soda Softening  
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ITEM	DESCRIPTION	COST
<b>A.</b>	<b>DIRECT PRODUCTION -</b>	
1)	Raw Materials : Chemicals: Assume lime @ 220,000 lbs @ \$ .05/lb	\$11,000
2)	Operating Labor : 12hrs/wk @ \$23/hr X 52wks/yr.	\$167,440
3)	Direct Supervision : \$45/hr @ 2080hrs./yr.	\$93,600
4)	Utilities : Electricity 170kwh/day @ \$.08/kwh	\$4,964
5)	Maintenance & Repairs: 10% of Capital (direct costs)	\$32,926
6)	Operating Supplies : 10% of Maintenance & Repair	\$3,293
7)	Sampling & Laboratory Charges -	
	Performance Monitoring :	
	Water Sampling / Sampling Analysis	\$12,000
	Sampling Operations	\$2,500
	Sampling Validation and Reporting:	\$5,000
		-----
	SUBTOTAL SAMPLING:	\$19,500
		-----
	TOTAL DIRECT PRODUCTION COST:	\$332,723
<b>B.</b>	<b>FIXED CHARGES -</b>	
1)	Depreciation @ 5% of Total Capital Requirement	\$25,682
2)	Local Taxes @ .2% of Total Capital Requirement	\$1,027
3)	Insurance @ .7% of Total Capital Requirement	\$3,595
		-----
	SUBTOTAL FIXED CHARGES:	\$30,304
<b>C.</b>	<b>PLANT OVERHEAD -</b>	
	Calculated @ 15% of Labor, Supervision, Maintenance & Repairs (includes up-keep of system, health and safety and misc. maintenance):	\$44,095
<b>D.</b>	<b>DISPOSAL COSTS -</b>	
	Solids-(Assume disposal as hazardous) 400 cuyd @ \$200/cuyd	\$80,000
		-----
	SUBTOTAL (Items A+B+C+D):	\$487,122
	CONTINGENCY @ 20%	\$97,424
		-----
	TOTAL ANNUAL OPERATIONS AND MAINTENANCE COSTS:	\$584,546
		=====